A MULTI-ATTRIBUTE MULTI-PARTY MODEL OF CHOICE: DESCRIPTIVE AND PRESCRIPTIVE CONSIDERATIONS

Howard Kunreuther[1]

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INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
2361 Laxenburg, Austria

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I. INTRODUCTION

Society has become increasingly concerned with the question as to how one evaluates the siting of technologically sophisticated projects which provide social benefits over a wide region but also may impose significant costs on certain groups. The recent debates on the future of nuclear power plants as a source of energy throughout the world highlights this point. A less publicized set of decisions is the siting of liquefied energy gas terminals in different parts of the world, the particular technology which serves as an illustrative example in this paper.

[1]The research report in this paper is supported by the Bundesministerium fuer Forschung und Technologie, F.R.G., contract no. 321/7591/RGB 8001. While support for this work is gratefully acknowledged, the views expressed are the author's and not necessarily shared by the sponsor. This paper is part of a larger project a group of us at IIASA are undertaking with respect to siting decisions of Liquefied Natural Gas facilities. The ideas presented here reflect helpful discussions with my IIASA colleagues--John Lathrop, Joanne Linnerooth and Nino Majone--as well as with David Bell and Louis Miller.

There are two primary features associated with these proposed projects which make them particularly difficult to structure analytically. First the decision affects many different individuals and groups in society rather than being confined to the normal relationship of a private market transaction such as when a consumer purchases food or an appliance from a store or firm. In the siting decision, each interested party has its own objectives, attributes, data base and constraints (Keeney 1980).

A second feature of these problems is the absence of a detailed statistical data base on the variety of different risks associated with either investing or not investing in a particular project. For example, if the construction of a nuclear power plant or LNG terminal is approved, then environmental and safety risks are created. By not building the project there are economic risks with respect to the future cost of energy to residences and businesses. Each interested party is thus likely to provide different estimates of the uncertainties and consequences of these risks. Hence it is particularly difficult to utilize what Majone and Quade (1980) call statistical rules of evidence to settle these differences.

The purpose of this paper is to develop a framework for investigating societal problems which have the above two characteristics. Section II provides a set of concepts which are relevant for characterizing the decision making process. In Section III these concepts are integrated into a descriptive model of choice, a multi-attribute multi-party model (MAMP) which has been developed at IIASA for structuring the process for siting LNG terminals in four different countries (Kunreuther, Lathrop, and Linnerooth 1981). The model will be illustrated using the California siting case. Section IV discusses how the current facility siting decision process

might be improved.

II. RELEVANT CONCEPTS FOR A DESCRIPTIVE MODEL OF CHOICE

DIFFERENT INTERESTED PARTIES

Facility siting debates vary in detail but there are a well defined set of stakeholders who can be classified into one of four general groups depicted in Figure 1. Let us briefly look at each of these interested parties in turn to better understand why potential conflict is likely to result when a specific project is proposed.

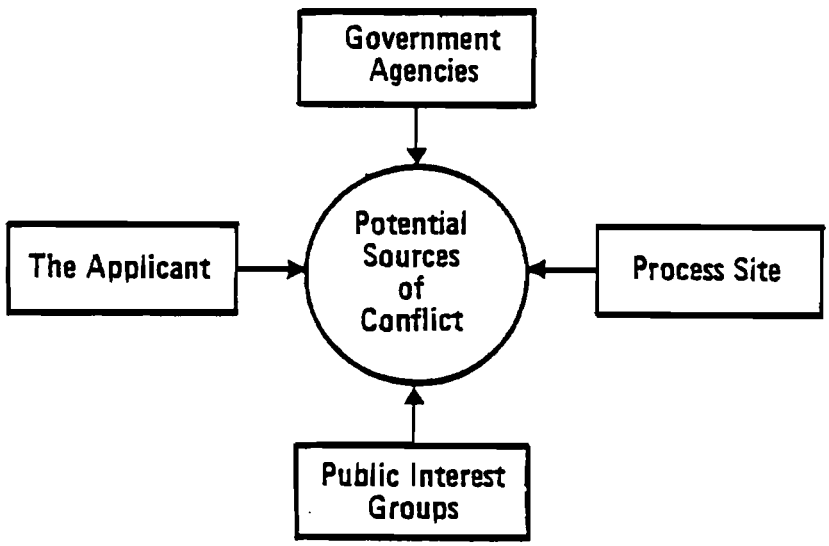

Figure 1. Relevant interested parties in facility siting decision.

The Applicant

Firms or developers who support the construction and operation of a facility have concluded that despite future uncertainties, the expected profits associated with the project exceed the potential costs. Their position is likely to be based on economic factors, although they may also be concerned with the safety risk.

Proposed Site(s)

Residents in a community that has been proposed as a possible site will have differing views of the situation. Those who own the property where the project is to be constructed have to determine whether the price the developer offers them is attractive enough. If the developer has eminent domain power (e.g., a public utility) then these residents may be concerned that a court will not award them a fair price for their property (O'Hare 1977). Others in the community may focus on the reduced property taxes or increased employment that a facility is likely to bring and hence favor the action. A third group may be concerned with the increased safety risk created by the facility and oppose the project.

Government Agencies

State and federal government agencies normally play the role of referee or arbiter in the decision making process, even though in many cases they have an interest in a particular outcome. Their regulatory actions, which are often constrained by legislation, influence the nature and distribution of the public's preferences and provide advantages to

some interests relative to others (Jackson and Kunreuther 1981).

Public Interest Groups

Recently we have seen the rise of very intense public interest groups. These organizations generally represent the interests and preference of one component of the public. For example, the membership of the Sierra Club is concerned with the effects that the siting of any new facility will have on the environment. Wilson (1975) and Mitchell (1979) have pointed out that those attracted to such organizations have strong, particular interests which dictate the agenda of the organization and influence the type of information that is collected and processed.

It should be clear from these brief descriptions that there is considerable room for potential conflict between groups once a specific site is proposed as an option. The relative influence of each of the parties in the process will depend on their composition as well as how well-defined their objectives are. Olson (1971) postulates that each person in a group allocates time and energy in proportion to the expected benefits (s)he receives. If this assumption is true, then it is less likely that individuals will devote more effort to supporting a group's cause as the size of the group decreases and the amount at stake for each individual increases.

Greater coherence of the group re common objectives and goals will also encourage actions by each of the individual members since everyone is fighting for the same cause. Local citizens groups where members are concerned that the proposed project threatens their safety, or environmental groups with a concern for land-use degradation from the project,

are thus likely to invest considerable resources into opposing the facility. These small but powerful contingents should be contrasted with the more diffuse set of individuals benefiting from the project but remaining passive because they do not feel that their own efforts will affect the outcome of the process (O'Hare 1977). As we shall see later in the California case, the actions of a local citizens group in one of the proposed sites had a significant impact with respect to the siting process.

SEQUENTIAL DECISION PROCESS

Another feature of the facility siting problem is that the process is characterized by sequential decisions. March (1978) notes that individuals and groups simplify a large problem into small subproblems because of the difficulty they have in assimilating all alternatives and information. Often constraints due to legislation and legal considerations dictate the order in which certain actions must be taken.

If the process is sequential in nature then the setting of an agenda is likely to play a role in determining the final outcome as well as the length of time it takes to reach it. By agenda setting we are referring to the order in which different subproblems are considered. There is strong empirical evidence from the field as well as from laboratory experiments (Cobb and Elder 1975; and Levine and Plott 1977) that different agendas for the same problem frequently lead to different outcomes.

There are two principal reasons for this. Once a particular decision has been made on a subproblem this serves as a constraint for the next subproblem. If the order of the subproblems is reversed then there

would likely be a different set of choices to consider. Secondly, each subproblem involves a different set of interested parties who bring with them their own set of data to bolster their cause. The timing of the release of this information may have an effect on later actions. For example, citizens groups normally enter the scene with respect to siting problems only when their own community is being considered as a possible candidate. The data on the risks associated with siting would be released at a slower rate (but perhaps with greater emphasis and more political impact) if only one site was considered at a time than if all potential sites were evaluated simultaneously.

ROLE OF EXOGENOUS EVENTS

Another important concept, which relates to the uncertainty of information on probabilities and losses, is the importance of exogenous events in influencing the decision process. Random events, such as disasters, often play a critical role in triggering specific actions to "prevent" future crises and call attention to the dangers associated with a particular technology. The small data base for judging the frequency of low probability events, coupled with systematic biases of individuals in dealing with concepts of chance and uncertainty, increases the importance of a salient event in the decisionmaking process. Tversky and Kahneman (1974) describe this phenomenon under the heading of availability, whereby one judges the frequency of a event by the ease with which one can retrieve it from memory.

Fischhoff, Lictenstein and Slovic (in press) summarize their recent experimental studies on perceived risks by cataloguing the nature of individual estimates on the probability of occurrence and consequence of different types of hazards. One of their principal conclusions is that these estimates are labile and likely to change over time because of salient events which are highlighted by mass media coverage. In a similar spirit, March and Olsen (1976) suggest that random events and their timing play a role in many organizational decisions because of the ambiguity of many situations and the limited attention that can be given to any particular problem by the interested parties unless it is perceived as being critical. They provide empirical evidence to support their theory using empirical studies of organizations in Denmark, Norway and the United States.

With respect to legislative decisionmaking Walker (1977) suggests the importance of graphically and easily understood evidence of trouble as an important factor in setting the discretionary agenda of the U.S. Congress or a government agency. He also suggests that the political appeal of dealing with a specific problem is increased if it has an impact on large numbers of people. To support these points, Walker presents empirical evidence on the passage of safety legislation in the U.S. Numerous examples of this process are also provided by Lawless (1977) through a series of case histories of problems involving the impact of technology on society. He points out that frequently:

> new information of an "alarming" nature is announced and is given rapid and widespread visibility by means of modern mass communications media. Almost overnight the case can become a subject of discussion and concern to much of the populace,

and generate strong pressures to evaluate and remedy the problem as rapidly as possible (p.16).

In the case of decisions such as the siting of facilities, exogenous events such as an LNG explosion or an oil spill may be sufficiently graphic and affect enough people to cause a reversal of earlier decisions, inject other alternatives into the process and change the relative strength of parties interested in the decision outcome. The mass media may play a critical role in focusing on these specific events and in many cases exaggerating their importance.

III. A MULTI-ATTRIBUTE MULTI PARTY MODEL OF CHOICE

The above concepts are now incorporated into a model of sequential decision making for large-scale projects such as facility siting. The approach, which has been influenced by the work of Braybrooke (1974), focuses on more than one attribute and involves many interested parties. Hence we have called it the Multi-Attribute Multi-Party (MAMP) model.[2] The MAMP model will be described using an illustrative example: the siting of a liquefied natural gas (LNG) terminal in California[3]. It is thus useful to provide a brief background on the nature of the siting problem.

LNG is a potential source of energy which requires a fairly complicated technological process that has the potential, albeit with very low probability, of creating severe losses. To import LNG the gas has to be

[2]For a more detailed description of the MAMP model see Kunreuther, Lathrop and Linnerooth (1981).

[3]For a more detailed discussion of the California Case see Lathrop (1981) and Linnerooth (1980).

converted to liquid form at about 1/600 the volume. It is shipped in specially constructed tankers and received at a terminal where it undergoes regasification and is then distributed. The entire system (i.e., the liquefaction facility, the LNG tanker and the receiving terminal and regasification facility) can cost more than $1 billion to construct (Office of Technology Assessment 1977). The siting problem in the United States revolves around the issues of whether LNG imports are in the national energy interest and if so, whether the proposed project is considered safe enough.

ELEMENTS OF THE MODEL

Figure 2 provides a schematic diagram of the MAMP model. The decision process can be separated into different rounds which are labeled by capital letters, A, B .... A round is simply a convenient device to illustrate a change in the focus of discussions either because (1) a key decision was taken (or a stalemate reached due to conflicts among parties) or (2) a change occurred in the context of the discussions due to an exogenous event, entrance of a new party or new evidence to the debate. A round is initiated by a formal or informal request by one or more of the interested parties. In California Round A began in September 1974 when the applicant filed for approval of three sites on the California Coast--Point Conception, Oxnard and Los Angeles--to receive gas from Indonesia.

No matter how a round is initiated it is characterized by a unique problem formulation which is presented in the form of a set of alternatives. There can be several decisions made in any round but by definition

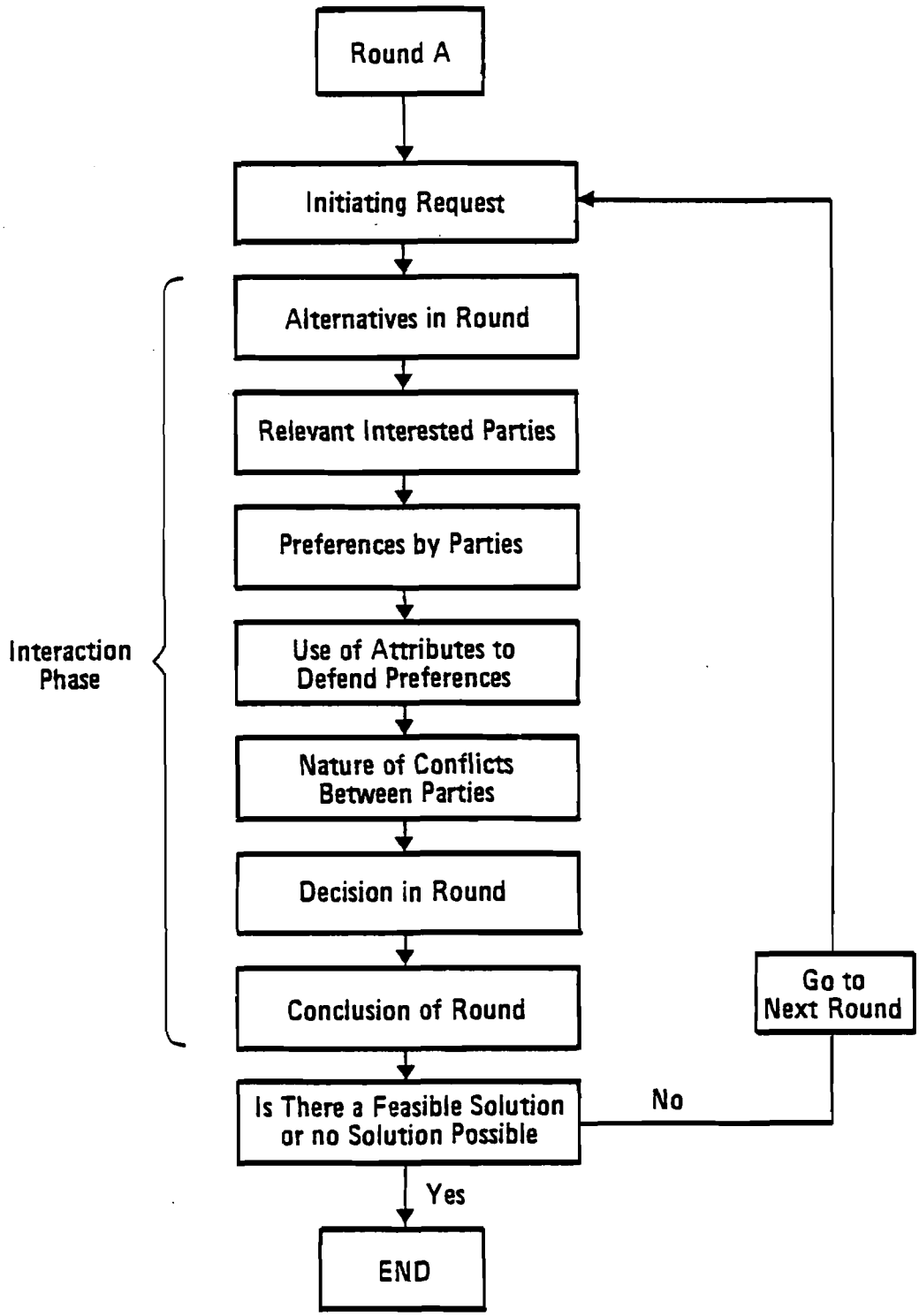

Figure 2. Multi-Attribute Multi-Party Model (MAMP) of choice.

they are based on the same set of alternatives. Each alternative is characterized by a set of attributes which may be viewed differently by each of the interested parties. In Round A the alternatives were whether one or more of the proposed sites for an LNG terminal was acceptable. There were four primary attributes used for the ensuing debate among the parties. The need for LNG and the risk of an interruption in the supply of natural gas were arguments for supporting the location of a terminal in at least one of the three proposed sites. Environmental and land use considerations suggested a non-remote site (Los Angeles, or Oxnard) while the risks to the population argued for siting the terminal in a remote area (Point Conception). Finally concerns about earthquake risk brought about opposition to the Los Angeles site, which was found to be crossed by a significant fault.

There were several interested parties in Round A which can be referenced to the four groups depicted in Figure 1. *The applicant* for the terminal was Western LNG Terminal Associates, a special company set up to represent the LNG siting interests of the three gas distribution utilities: Southern California Gas Company, Pacific Gas and Electric, and El Paso Natural Gas Company. At the *proposed sites*, each of the city councils evaluated the proposed terminal in their jurisdiction by looking at the tax revenues and jobs it promised to provide. These positive features had to be weighed against the negative impacts that the facility might have on land use and risk to the population.

With respect to *government agencies*, the Federal Energy Regulatory Commission (FERC) determines whether a proposed LNG project is in the public interest and should be allowed and the California Coastal

Commission (CCC) has the responsibility of protecting the California coastline. Finally, the *public interest groups*, represented by the Sierra Club and local citizens groups, were primarily concerned with safety and environmental issues.

Each of the interested parties states its preference over the different alternatives and constructs arguments to defend its preference by focusing on different attributes. During this interaction phase certain decisions are made. In the case of Round A in California two key decisions were taken. First, the CCC favored Point Conception over the non-remote sites claiming that the decrease in population risk outweighed the increase in environmental degradation. Second, the FERC disapproved of the Port of Los Angeles because a recently discovered earthquake fault increased the seismic risk above an acceptable threshold.

Round A was concluded with a potential stalemate perceived by the gas industry. Los Angeles would not receive federal (FERC) approval. Oxnard was not likely to receive state (CCC) approval and Point Conception faced difficult challenges at the county and state levels because of its adverse land-use impacts. We have summarized the elements of Round A in Table 1.

The siting process in California can be characterized by four rounds (A...D) as shown in Table 2. Round B resulted in the passage of the LNG siting Act of 1977 which was designed to break the stalemate at the end of Round A. Its principal feature was that the CCC nominates and ranks potential sites for an LNG terminal in additional to those which the Western LNG Terminal Associates applies for. The California Public Utilities Commission, the principal state body involved in power plant issues,

Table 1: Elements of Round A

Problem Definition:	Should any of the proposed sites be approved? That is: Does California need LNG, and if so, which, if any, of the proposed sites is appropriate?
Initiating Event:	Applicant files for approval of three sites.
Alternatives:	Site at Point Conception: Site at Oxnard: Site at Los Angeles: Site at any combination of

Interaction:

Involved Parties		Attributes Used as Arguments	
Applicant	P_1	Supply Interruption Risk	
FERC	P_2	Supply Interruption Risk Earthquake Risk	
CCC	P_3	Population Risk	
City Councils	P_6	Population Risk	Land Use Quality
Sierra Club	P_7	Population Risk	Land Use Quality
Local Citizens	P_8	Population Risk	Land Use Quality

Key Decisions:

1. Point Conception preferred to Oxnard and Los Angeles, based on the fact that the decrease in population risk outweighs the increase in environmental degradation.

2. Los Angeles would not be approved because the seismic risk is greater than an acceptable threshold.

Conclusion:

Applicant perceives a stalemate, i.e., that no site is approvable without long delay.

Table 2: Summary of Rounds in California LNG Siting Case

		Date
ROUND A		
Problem Definition:	Should the proposed sites be approved? That is: Does California need LNG, and if so, which, if any, of the proposed sites is appropriate?	
Initiating Event:	Applicant files for approval of three sites.	September 1974 (34 months)
Conclusion:	Applicant perceives that no site is approvable without long delay	July 1977
ROUND B		
Problem Definition:	How should need for LNG be determined? If need is established, how should an LNG facility be sited?	
Initiating Event:	Applicant and others put pressure on state legislature to facilitate LNG siting.	July 1977 (2 months)
Conclusion:	New siting process set up that essentially assumes a need for LNG, and is designed to accelerate LNG terminal siting.	September 1977
ROUND C		
Problem Definition:	Which site should be approved?	
Initiating Event:	Applicant files for approval of Point Conception site.	October 1977 (10 months)
Conclusion:	Site approved conditional on consideration of additional seismic risk data.	July 1978
ROUND D		
Problem Definition:	Is Point Conception seismically safe?	
Initiating Event:	Regulatory agencies set up procedures to consider additional seismic risk data.	
Conclusion:	(Round still in progress)	

selects a site from the CCC list, not necessarily the top ranked site. In Round C which occurred during the summer of 1977 the CCC ranked four sites (Camp Pendleton, Rattlesnake Canyon, Point Conception, and Deer Canyon) in that order and the CPUC chose Point Conception, conditional on it being a seismically safe location. Round D is still in progress with the FERC and CPUC examining seismic data which will determine whether Point Conception is seismically safe.

Whether an LNG terminal will ever be sited at Point Conception is an open question since the enthusiasm of the applicant for an LNG terminal has now waned considerably since they proposed the three sites back in 1972. In addition, there are two sets of wealthy landholders owning adjacent tracts of land to Point Conception: the Hollister and Bixby Ranches. These landholders are attempting to do everything in their legal power to prevent the siting process at Point Conception and so far have managed to stall any action.

INTERPRETATION OF THE MODEL

The MAMP decision process in California reflects the basic concepts which were outlined in Section II. As indicated by the scenario of the four rounds, there were *different interested parties* who interacted with each other at each stage of the process. There were three broad categories of concern which are relevant to this problem: risk aspects, economic aspects, and environmental aspects. Each of these concerns can be described by a set of attributes. Table 3 depicts an interested party/concern matrix showing the main attributes considered by each of

Table 3. Party-Concern Matrix.

PARTIES / CONCERNS	APPLICANT UTILITY	FEDERAL	STATE GOV'T			LOCAL GOV'T	INTEREST GPS	
		FERC	CCC	CPUC	LEG		SIERRA CLUB	LOCAL CITIZEN GP
ECONOMIC								
Need for gas	●	●		●	●			
Profit considerations	●							
Price of gas	●	●		●	●			
Local economic						●		
ENVIRONMENTAL								
Air quality		●		●	●		●	
Land use		●	●	●	●	●	●	●
RISK								
Population	●	●	●	●	●	●	●	●
Earthquake		●	●	●	●			

the relevant groups over the seven year period. It is clear from this table that each of the parties brought to the debate their own special interests. The applicant's primary concerns are earning profits for shareholders and delivering gas reliably to consumers. Hence the emphasis on the need for gas, profit considerations and price of gas as the relevant factors. The federal and state government agencies concerns were specified by legislation; local governments compared the economic benefits with environmental and safety factors. Public interest groups, like the Sierra Club and local citizens groups, focused their attention on the environmental aspects and safety risks associated with the project.

The case also illustrates the importance of a small but powerful interested party--the Oxnard citizens group--in influencing legislative actions. Until the publication in 1976 of a worst case scenario associated with a proposed $300 million terminal in Oxnard, there was almost unanimous agreement by all stakeholders that this community would be an ideal site for an LNG terminal. At the time even the Sierra Club was in favor of this location. (they changed their feelings about Oxnard in 1977). A worse case scenario indicated that a spill of 125,000 cubic meters of LNG from all five tanks on a tanker would cause a vapor cloud which would affect 50,000 people. Residents could look on a map to determine whether the cloud covered one's own house (Ahern 1980). No estimate of a probability was attached to this scenario.

The graphic depiction of these consequences generated a public reaction by a small group organized by concerned citizens of Ventura County. The California legislature was influenced by this public reaction. One legislative staff member stressed that it was not possible to allow a

site that would lead to a large number of deaths in a catastrophe.[4] Hence, new siting regulations were passed stating that no more than an average of 10 people per square mile could be within one mile of the terminal and no more than 60 within four miles of the terminal. The President's National Energy Plan incorporated similar population guidelines which effectively ruled out any high density areas as candidates for an LNG terminal.

Interestingly enough the risk assessment used by the citizens group at Oxnard was only one of three commissioned by different interested parties for this site. The assessments commissioned by the applicant and the FERC showed very low numbers and were interpreted to mean that the risk was acceptable. The risk assessment commissioned by the Oxnard municipal government and used by the citizens group also had low probabilities, but in its report it described maximum credible accidents without the accompanying probabilities (Mandl and Lathrop 1981).

The *sequential decision process* is self-explanatory based on the four rounds depicted in Table 2. This process may facilitate decisions at each stage by limiting the number of parties but it can have negative long-range consequences. For example, the need for imported natural gas has greatly diminished in California but the possibility of siting a terminal is still alive. Point Conception has been deemed an acceptable site subject to a seismic risk study. Due to the nature of the siting process, the only way this site would be unacceptable is if the seismic risk was found to be too high. Rather than stating that California may not need LNG, the

[4]This comment was made to John Lathrop in an interview in Sacramento, California, in July 1980, regarding the siting process of an LNG terminal.

relevant interested parties have preferred to delay the findings of the seismic risk studies (Lathrop 1981).

Another example of the long-range negative effects of the sequential constraints is the case of a supply interruption risk. Initially the applicant proposed three separate sites to minimize the risk of California having a shortage of natural gas. When the decision process eliminated two of the three proposed terminals, Western Associates proposed the construction of a large facility at Point Conception capable of producing a throughput of 58,000 m^3 LNG/day, equivalent in energy flow to roughly 15 modern nuclear reactor units (Mandl and Lathrop 1981). By concentrating the facilities at one port the supply interruption risk will now likely be increased rather than decreased, if Point Conception is approved and actually utilized.

Finally turning to the *role of exogenous events* in California there is one incident which had an impact on the decision making process. In December 1976 the Los Angeles City Council voted to allow work to begin on an LNG terminal in San Pedro Bay. The following day an explosion ripped the oil tanker Sansinea in Los Angeles harbor, leaving 9 dead and 50 injured. A week later the City Council commissioned a study as to the relative safety of the proposed site. They later approved the terminal. This explosion, although it had nothing to do with liquefied natural gas, alerted many Californians to the potential dangers of LNG.

On a more general level, two disasters in other parts of the country illustrate the importance that exogenous events have had on the decision process with respect to LNG siting and regulations.

In 1973 an LNG tank in Staten Island, New York, exploded and the roof collapsed burying 40 workers. There was no LNG in the tank but it had seeped through the insulation and caused a huge fire. A result of this explosion was the increased concern with the dangers of LNG by Staten Island residents. The neighborhood organization which was formed a year before the accident, attracted considerable attention and interest because of the media coverage of the tank explosion. In the context of the MAMP model a new interested party played a key role because of an exogenous event. What may have been a foregone decision regarding the location of an LNG tank in Staten Island became problematical (Davis 1979).

The worst LNG accident occurred in 1944 when the storage tank operated by the East Ohio Gas Company in Cleveland ruptured, spilling LNG on adjacent streets and sewers. The liquid evaporated, the gas ignited and exploded, resulting in 128 deaths, 300 injuries and approximately $7 million in property damage. An investigation of this accident indicated that the tank failed because it was constructed of 3.5% nickel steel, which becomes brittle when it comes in contact with the extreme cold of LNG. All plants are now built with 9% nickel steel, aluminum or concrete and the storage tanks are surrounded by dikes capable of containing the contents of the tank if a rupture occurs (Davis 1979). This example illustrates the impact of a particular incident on new regulations, which otherwise may not have been passed.

IV. IMPROVING THE DECISION PROCESS: PRESCRIPTIVE ANALYSIS

The siting process for LNG terminals in California has provided a graphic description of the conflicts which exist between different interested parties, each of whom have their own goals and objectives. The party/concern matrix depicts the different attributes used to defend positions; the MAMP model reveals the dynamics of the decision process and the relevant constraints which determined the outcomes at the end of each of the different rounds.

LESSONS FROM THE MAMP MODEL

A retrospective view of the situation through the eyes of the MAMP model provides the following insights which may have relevance for prescription.

1. There is little articulation of value judgments by the different parties. Each of the groups has a set of objectives and related attributes which they are willing to articulate but there has been no statement by anyone as to the importance weights assigned to the different attributes in the problem. This observation coincides with Ward Edwards experience in attempting to use multi-attribute utility analysis in evaluating alternative school desegregation plans submitted by external groups to the Los Angeles School Board. He has noted that the interested parties in a societal decision problem are unlikely to reveal their value structure because this information would then be public

and they would be accountable for numerical judgments (Edwards 1981). For this reason it will be difficult to utilize this technique as a way of determining preferences between alternatives.

2. Constraints guiding the decision process are not stable but may change over time as new information is injected into the process by one or more interested parties. An interesting example is the present concern that seismic risk is a potential problem for siting a facility at Point Conception, even though this risk had not surfaced in earlier discussions of the feasibility of the site.

   Another illustration is the ability of the Oxnard citizens group to influence new legislation on siting criteria by focusing on the number of deaths from a catastrophic accident rather than on the extremely low probability of such a disaster actually occurring. These examples illustrate the point made by Majone (in press) that actual policies are determined in the world of institutional choice where each of the interested parties are attempting to modify rules of the game which constrain them from achieving their goals and objectives.

3. The siting of sophisticated technologies is a process that is not well understood scientifically so that there are no measures of risk which can be pinpointed using statistical analysis. Hence each of the interested parties has an opportunity to focus on different measures to support their position. The conflicting risk assessments for evaluating the safety of an LNG terminal in proposed sites has been well documented by Mandl and Lathrop

(1981) for the four IIASA case studies. Each of several different interested parties, commissioned a special risk study and used the results for their own purposes.

Given these observations what can be done to improve the situation? One of the most important aspects of the MAMP descriptive model is that it enables the policy analyst to focus on the actual siting process and to evaluate its success on the basis of several different dimensions. The standard analytic tools such as multi-attribute utility analysis or cost/benefit analysis have normally focused on outcomes rather than process. There is no reason why one cannot focus on how well different procedures score with respect to a well-defined set of objectives.

The first step in undertaking this type of analysis would be to specify the relative importance of different attributes one would like a process to satisfy. One of these attributes might be related to how well the final choice performs with respect to resource allocation, but there is also likely to be a set of attributes which reflect the way different interested parties feel about the process as well as the outcome? For example, did each interested party have an opportunity to voice its position? Were a wide enough set of alternatives considered so that the parties felt that a choice was actually being made? These factors may be important in some type of cultural settings but less relevant in others. The policy analyst can also point out that a more elaborate process takes time, another dimension to be considered in the evaluation procedure. By articulating the types of tradeoffs which have to be made in choosing one type of procedure over another, the analyst can provide guidance to policy makers

as to what the decision process they may want to consider in the future.

THE USE OF GERT

The MAMP model also may be a useful tool for analyzing how alternative procedures are likely to fare for a given problem context. In reality the decisions made in any round are probabilistic with the chances of different outcomes determined by the party/concern matrix and the procedures which one employs. One way to modify the MAMP model to incorporate these elements of uncertainty is to employ the concepts of another technique--GERT (Graphical Evaluation and Review Technique)--to structure the process. GERT is a combination of network theory, probability theory and simulation and was developed by Alan Pritsker (1966) to analyze the terminal countdown on an Apollo space system.[5]

The basic features of GERT can be illustrated through a prospective view of the California siting decision. Figure 3 depicts the scenario using the symbolic features introduced by Pritsker. The two key concepts for understanding a process are activities and nodes. An activity is an actual operation or process which takes time and consumes resources. A node is a point in time which either represents the start or completion of one or more activities. Activities are represented by arrows while nodes are represented by either circles or loops.

[5]For an excellent description of the modeling features and capabilities of GERT including its application in real world problems see Moore and Clayton (1976).

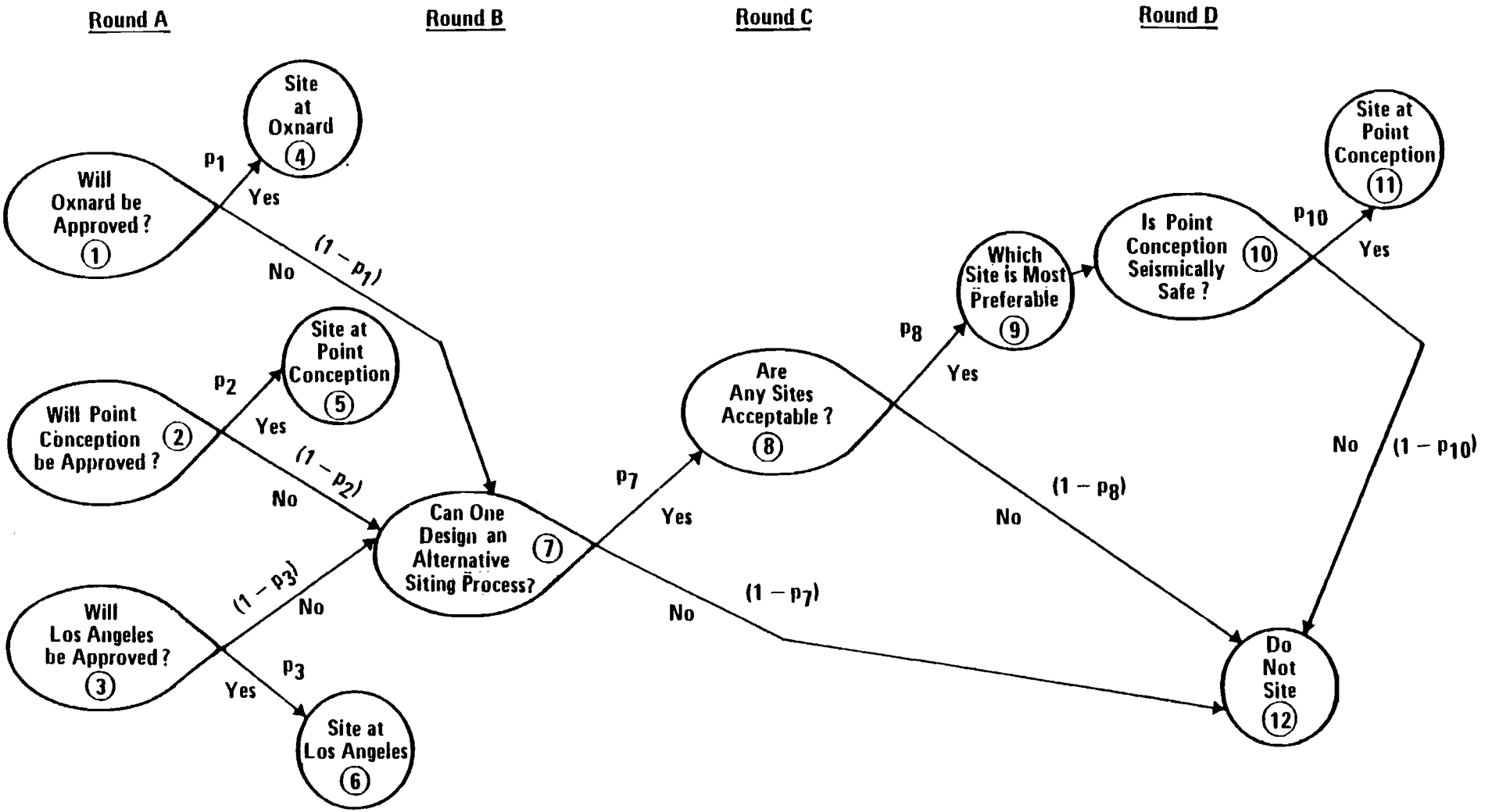

Figure 3. GERT applied to the California siting decision process.

To illustrate this graphical notation consider Figure 3. Nodes 1, 2, and 3 represent the start of the activities in Round A associated with siting at Point Conception, Oxnard, and Los Angeles. For simplicity each of the questions inside the three nodes is assumed to have either a "yes" or "no" answer,[6] and the respective probabilities of a "yes" answer are given by the values P_i $i=1,2,3$. The policy analyst, in consultation with different interested parties, could assign appropriate figures to these probabilities.

The two different shapes of the nodes reflect the nature of the possible outcomes for activities emanating from them. The looped nodes such as 1,2, and 3 signify that the outcome is probabilistic. Node 9 is represented by a circle indicating that the outcome is certain (i.e., there will be a ranking the sites given the fact that one or more of them have been found to be acceptable (from Node 8)). The outcomes of the process will also be circles as indicated by Nodes 4-6 and Nodes 11 and 12.

The GERT approach is considerably more sophisticated than Figure 3 implies. Estimates can be made for the expected completion time of each activity with appropriate probabilities reflecting uncertainty as to how long a given process may take. In addition one can have network looping, whereby if one reaches a certain stage of the process one must return to an earlier node.

The use of GERT to structure the key questions and activities depicted in the MAMP model provides a vehicle for prescriptive analysis. It enables the policy analyst to develop alternative scenarios and likely

[6] In reality there would undoubtedly be a variety of possible answers to these questions. For example, a response could have been a "Conditional Yes" subject to more data on seismic risk. For ease of exposition we are also assuming that the decisions regarding the three sites are independent of each other when in reality they are likely to be interrelated.

outcomes by changing the nature of the decision process. The following types of questions could be directly addressed:

- What is the likely impact on the different activities and nodes if some of the existing constraints are relaxed? For example, suppose that experts were explicitly brought into the process to attempt to arrive at consensual judgments regarding specific risks and that the interested parties have to abide by their findings. What impact would this have on the likely outcomes?[7]
- What would be the impact on the process if certain parties were given power which they currently do not have? For example, suppose that a specific regulatory agency was given full authority to rank and approve a specific site in California. What difference would this make on the scenario and final outcome?
- What would happen if there was a change in the way alternative sites were introduced into the picture? For example suppose the gas companies decided to propose only one site at a time for locating a terminal. How would this affect the interaction between different interested parties and the alternative outcomes? In this type of scenario one would first have to determine the order of the sites to be introduced and the relevant nodes and activities should a particular site by approved or deemed infeasible?

[7] A discussion of the potential role of experts in the LNG siting decision in California appears in Stoto (in press).

EFFICIENCY AND EQUITY TRADEOFFS

These alternative scenarios provide a menu of options which can be considered by the relevant interested parties. They do *not* imply that one process is better than another. This judgment reflects the tradeoffs between efficiency and equity that have become so prominent in the recent literature on social choice. Schelling (1981) has provided an interesting perspective on this problem by indicating that in theory a pricing system can be combined with appropriate income transfers to achieve efficient outcomes which are also equitable to different groups of people. The reality of the situation, as Schelling is quick to point out, is that political constraints may not permit one to use the pricing system. One may not be able to reallocate funds to a particular group because of budget restrictions. Similarly a specific governmental body may have responsibility for deciding on a particular question and will base its decision so it best satisfies its own goals.

The MAMP model coupled with GERT can provide insight as to when political considerations are likely to foreclose certain outcomes which may have desirable economic features. For example, a particular scenario may reveal that a community is likely to be opposed to a given site and will fight hard to stop its approval because they feel that the increased risks which they must bear are too high. If this project is socially beneficial, then it may be useful to investigate some way to compensate the local community who will suffer from the project.

O'Hare (1977) has proposed a particular type of compensation scheme whereby each community proposed as a potential site deter-

mines a minimum level of per capita compensation such that it is willing to make a legal commitment to have the project in their backyard if the compensation is paid. The applicant would utilize this compensation as part of his calculations as to the relevant costs associated with locating the facilities in community A, B or C. The final decision would then be made by the applicant taking into account the amount of compensation it would have to pay residents in each of these three localities.

This type of system would only be applied to potential sites that had satisfied specific governmental criteria related to safety and environmental risk. O'Hare recognizes that there will still be some individuals in a given community who will be compensated more than they need to be and others who will not be rewarded enough. He also recognizes that for such a system to be implemented there must be good information on the relevant costs, including an environmental impact statement, and that the system has to be designed to overcome the incentive to overbid.

Whether or not some type of compensation scheme is a useful policy prescription depends on the specifics of the situation. In this connection, it would be interesting to ask what type of payments would have been required to appease the citizens of Oxnard so that an LNG terminal could have been located there? What would the Sierra Club require in payments so that they would support a site which might have adverse environment effects? These questions can only be answered in a real world problem context. They do reflect an increasing concern of economists and lawyers in dealing with windfalls or wipeouts from specific actions which involve the public sector. Hagman and Misczynski (1978) in their comprehensive study of the subject believe that windfalls should be partially recaptured

to help compensate for wipeouts. They propose a number of alternative mechanisms for ameliorating this problem ranging from special assessments to development permits. These types of policy instruments could also be investigated in the context of specific siting problems.

After all is said and done the final outcome is likely to represent some type of balance between the political constraints and economic criteria. As Wildavsky (1981) has pointed out:

> The criterion of choice in politics and markets is not being right or correct as in solving a puzzle, but agreement based on interaction among partially opposed interests (p.133)

The MAMP model will not tell any politician how one should deal with the equity/efficiency dilemma but at least it uncovers some of the specific causes of these conflicts. How one actually improves the process is a challenge for the future.

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